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This investigation has suggested a possible physical cause for the position of the ecliptic plane which, so far as I am aware, has not been satisfactorily accounted for. It is purely speculative and I know of no test which would be adequate, particularly as it rests upon the theory of capture which is far from being established. This explanation was suggested by the fact that the ecliptic intersects the galaxy not far from the extremities of the axis of preferential motion. There is some evidence that the two star streams may be in reality parts of a *curved* stream, the so-called axis of preferential motion being in reality a tangent to that curve. In my opinion such a conception best satisfies the observed conditions. Radial velocities indicate maxima to the *south* of both extremities of the so-called ellipsoidal axis. This brings the intersection near 18^h in the general region of what appears to be one star stream.

The centers of preference of the parabolic comets near the longitudes of the apex and antapex of solar motion are also both some 10° or 15° south of the ecliptic. If now the planets were captured, it is not difficult to outline a cause for the position of the ecliptic. Bodies moving with a stellar stream (not to be more definite at present) might be picked up by the Sun and if acted upon by a resisting medium, have their orbits rendered nearly circular. By mutual perturbation their orbits would tend to assume a common or 'invariable plane.' The addition of the masses of the satellites, comets and asteroids would not greatly disturb this plane, once established. This accounts for only one coordinate of the plane. The other we must suppose to be the mean of the group and as far as we know, at present, accidental.

This hypothesis is admittedly speculative and further discussion at this time does not seem warranted.

DISCOIDAL STRUCTURE OF THE LITHOSPHERE[1]

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Communicated by J. M. Clarke, July 15, 1919

Underlying the thesis here presented are the following postulates:

a. The lithosphere is heterogeneous as to density;

b. The lighter and heavier masses are of notable dimensions, varying from a hundred to several thousand kilometers in diameter;

c. Both lighter and heavier masses are distributed throughout continental areas and oceanic basins, but the lighter masses prevail in the continents and the heavier masses beneath the oceans;

d. The prevailing structure of deep-seated rocks is a foliated one and is the result of crystallization in response to appropriate conditions of stress and temperature;

e. Stresses competent to orient foliation in the elastic earth are set up by the effort of lighter and heavier masses to assume positions of isostatic equilibrium. These stresses are general, but they are localized and intensified by unloading and loading of adjacent areas through the process of erosion.

f. Periodic rises of temperature, local recrystallization, and local fusion of moderately deep-seated rocks result from the outward flow of the internal heat of the earth.

g. The strength of rocks increases with increasing pressure, as shown by Adams, but not as rapidly as the load increases from the surface of the earth downward. There is, therefore, a level at which the load equals the strength of any rock. Below that level for the strongest rock the earth is a potentially failing structure, which will fail by recrystallizing or by shearing under a differential stress which equals the critical load.

h. High temperature and fusion are potent factors in producing failure of the rigid lithosphere under its own weight.

It is obvious that these postulates rest upon the work of many investigators, among whom are Hayford and Bowie on gravitation, Dutton, Gilbert, and Barrell on the strength of the lithosphere, Van Hise, Leith, Johnson, and Bowen on schistosity, and Chamberlin on the origin of the earth and its internal heat. The contribution which this paper seeks to make is one toward an explanation of the mechanics of the lithosphere. Its conclusions, if valid, bear upon the growth of mountains, the deformation of superficial rocks, the distribution of volcanoes, the connections between continents, and the permanence of ocean basins.

The argument which leads to the recognition of the discoidal structure of the lithosphere proceeds as follows:

From an early stage of the growth of the earth onward the lighter and heavier masses of the elastic lithosphere have tended toward an equilibrium which may be described as an equilibrium in isostatic adjustment. It is conceivable that the departure from equilibrium may at some time have been such that the stresses set up in the lithosphere were adequate to cause flow and mass movement, until a close approach to complete isostatic equilibrium was reached. But the present departure from equilibrium is not of such a magnitude, nor is it likely that there has been so great a departure during any stage of geologic time known to us. The stresses due to differences in weight of adjacent masses of lighter and denser material, even when they are intensified by erosion of broad surfaces to a peneplain and by correlative loading of basin margins, are regarded as quite incompetent to overcome the strength of underlying rock masses, whose rigidity increases with load.

Nevertheless, the effort toward isostatic equilibrium produces non-uniform stresses which are long enduring and persistent in direction. In any mass which was lighter than its environment the direction of least stress would be vertically upward and the directions of greater stresses would be horizontal. Under any mass which was heavier than its environment the direction of greatest stress would be vertical and the directions of least stresses would be horizontal. If the lighter and heavier masses be in elastic continuity with one another, the upward stress in the former and the horizontal stress under the latter would combine to form a resultant which would rise in a curve from below upward. Thus the zone embracing the adjacent parts of both columns would be subject to a curved stress, which would proceed outward and upward from under the heavier mass. Stresses of this character appear to be a necessary result of a lack of equilibrium among the masses or elements of the elastic lithosphere.

The law of crystalline orientation in response to stress, as developed by Van Hise, Leith, and Bowen, requires that foliation shall grow in the direction of least stress. If, then, rocks crystallize or recrystallize, through the influence of rising temperature and altering solutions, in adjacent masses which are pervaded by the curved stress due to isostatic inequilibrium, the resulting foliation should be oriented in a curve corresponding to that stress. The foliation should be horizontal under the heavier element, should approach verticality under the lighter element, and should curve upward continuously from under the former toward the surface of the latter.

The quantitative value of the least stress which will orient foliation under the exceedingly complex conditions of metamorphism has not been determined. It must not be confused with the differential stress required to produce mechanical flowage. Adams has demonstrated the latter to be very great. The former is a stress which is within the elastic limit and may safely be regarded as relatively very small.

More important than amount of stress are the characteristics of non-uniformity, as distinguished from hydrostatic pressure, persistence in direction, and continuity of action during prolonged periods. These conditions are regarded as giving effectiveness to the stresses propagated in the elastic, rigid rocks far beneath the surface by imperfections of isostatic equilibrium.

The postulated directive stresses tending to orient foliation in curved surfaces have coexisted with conditions favorable to recrystallization since an early stage in the growth of the earth, under the planitesimal hypothesis. Under that hypothesis any resulting structure and its effects were characteristic of the growing earth and still pervade its mass from near the surface to the depth to which crystalline textures endure. Also under any other hypothesis of the earth's past history, which recognizes the effects of heterogeneity as to density and the periodicity of dynamo-metamorphism, structures involving curved foliation should result from isostatic stresses.

Upon the preceding reasoning is based the postulate of a discoidal structure of the lithosphere.

The condition for the development of curved surfaces of foliation exists wherever isostatic equilibrium is imperfect. It is obviously most effective where erosion and sedimentation are active. It is not limited to any particular section of the border zone of any lighter or heavier mass which is not in equilibrium, but extends around each such heavier mass and invades the area of each such lighter mass. Since the curves of strain and the resultant foliation dip under the heavier masses from all sides, those masses have a discoidal structure. They may be designated as discs. They are regarded as composed of a series of foliae, which are convex downward and which make up the mass of the disc to a depth of several hundred kilometers. Their outcropping margins will include wider or narrower zones of the lighter structural masses. Between the discs may lie masses which, by reason of the fact that they do not pertain to the heavier disc-shaped masses, belong to the lighter masses. These may be called interdiscs. Their cross section in a vertical plane would present a more or less broadly truncated triangle, whose truncated upper surface would vary from sub-continental to merely isthmian widths.

Thus the lithosphere would superficially exhibit three structural types: (1) the surfaces of the heavier discs, depressed by gravitative adjustment and more or less deeply covered with water or continental sediments. The dominant characteristic of the underlying masses is high density. It is a permanent characteristic and its effects are permanent and continuous. They should not be confused with the temporary effects of orogenic movements, which may also result in superficial depressions; (2) the surfaces of the lighter interdiscs, riding high and covered with the sediments of epicontinental seas, or exhibiting an approximately vertical foliation where denuded to metamorphic rocks; (3) the marginal zones of discs and interdiscs, characterized by extrusion of igneous rocks and orogenic disturbances. Where a broad light mass or structural element lies adjacent to a broad heavy element, as along the Pacific Coast of North America, the zone of marginal deformation may be very wide. Where, on the contrary, two heavy elements are nearly tangent, the zone of disturbance may be exceedingly narrow, as the Isthmus of Panama.

The hypothesis of discoidal structure may best be tested by the facts of the earth's major features and their relations to igneous intrusion and extrusion, to regional, periodic diastrophism, and to orogeny. Certain lines of investigation are suggested in what follows.

Are igneous rocks distributed around deeps, as would be required by the discoidal hypothesis?—Let it be assumed that magmas originate, as postulated by Chamberlin, through local fusion in the outer few hundred kilometers of the lithosphere. Molten material gathering in the foliae beneath a disc would be guided by the foliation toward the surface and would appear in or near the outcrop of the margin of the disc. By postulate any disc is indicated on the surface by an oceanic deep or a continental basin. The relation of volcanoes and also of geologically recent batholiths to oceanic margins has long been recognized. As bathymetric observations accumulate a more detailed relation to individual deeps is noticeable. The most conspicuous examples are the Windward Islands, sometimes called the "Necklace of the Caribbean," and the Alaskan, Aleutian, and Japanese volcanic chain.

Does diastrophism exhibit that periodicity with reference to the larger deeps which we should expect if each deep constitutes a structural unit?—It is well established that the opposite coasts of the North Atlantic have periodically suffered similar and contemporaneous deformation, and the same is true of the encircling lands around the Pacific Ocean.

Have the diastrophic activities of separate great deeps been non-contemporaneous to the extent which would give to each an independent character peculiar to itself?—That the diastrophic activities of the Atlantic and Pacific basins are incommensurate on the geologic time scale is a fact which constitutes the gravest difficulty in the assumption of universal periodicity. If diastrophism be due to an ultimate cause, operating periodically upon the inner mass of the earth, such as the accumulation of internal heat, an explanation of the diverse periodicity of different oceanic basins must be sought through the mechanism which registers the effects at the surface more quickly in one region or more slowly in another, as the case may be.

Do the mechanics of deformation of the lithosphere, as expressed in the effects of compression, conform to the structures which should follow from the postulated discoidal structure?—Under general tangential stress a spherical shell composed of discs and interdiscs should shorten by riding up of the margins of the discs upon the interdiscs. If the disc were competent to sustain itself by partial bridging, its whole mass would rise; if, as must generally if not always have been the case in the lithosphere, the disc be too wide and too weak to support itself, the margins only would be raised, the mass bending or fracturing as conditions demanded. The marginal zones should exhibit over-thrusts from the basin side and incidental phenomena of folding with minor over- and under thrusting. The facts of mountain structure appear to conform to these requirements. The folded and overthrust structures of the Appalachians and the faulted and upthrust structures of the Pacific ranges of California appear to find an intelligible explanation on the basis of the discoidal theory.

Do the trend lines of mountain chains conform in plan to the postulated discoidal structure?—To answer this question in detail will require an analysis of the earth's surface into discs and interdiscs, but the trend lines of the mountain chains of Europe, Asia, and the two Americas, as developed by Suess, do conform in plan to the obvious depressions within and around those continents. It must be recognized, however, that a long narrow depression filled with sediment may be so compressed and displaced as to become part of the continental interdisc. This is a well known geological occurrence, the transformation of a geosyncline into a mountain range, but it cannot in every such case be assumed that the geosyncline corresponded to a dense underbody. Other mechanical conditions may produce subsidence. With this reservation, however, I believe that the directrices of mountain chains can be shown to wind around discoidal masses.

Does the discoidal theory suggest any solution for the temporary intercontinental land connections which are demonstrated by biologic evidence?—The present isthmian connection between North and South America may be regarded as a typical case of intercontinental bond established by marginal uplift and extrusion of igneous rocks between the Caribbean and eastern Pacific discs. Similar connections may readily be traced between South America and Africa by two different routes. A connection between North America and Europe, via Greenland, Iceland, and England, such as has often been suggested, finds a rational explanation through its relation to the deeps of the North Atlantic. Oceanica may be intelligently linked up and explained.

If the establishment of isthmian connections be explicable according to the discoidal theory, can their subsequent submergence also be accounted for?—According to the discoidal theory, the source of very large masses of igneous rocks lies in the base of the discs. The extrusion of the melt is accompanied by subsidence of the central portion of the disc, which in turn and in time may be succeeded by slipping down of the elevated margins. The mechanism appears to be workable. It requires, however, fuller elaboration than can here be given to elucidate it. These concepts are obviously consistent with the permanency of oceanic basins and continental masses.

In addition to the tests proposed by these general questions, the theory should be tried by the more exacting requirements of the mechanics of deformation. This has been attempted and not without reasonably satisfactory results. The structure of the Pacific ranges of California has been discussed before the Geological Society of America and the LeConte Club of California, and the paper will shortly be offered for publication.

[1] Abstract of a paper presented to the Geological Society of America at the Pasadena Meeting of the Cordilleran Section.

RECENT SIMULTANEOUS MEASUREMENTS OF THE SOLAR CONSTANT OF RADIATION AT MOUNT WILSON, CALIFORNIA, AND CALAMA, CHILE

By C. G. Abbot

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Read before the Academy, April 29, 1919

For the past fourteen years, with the exception of the year 1907, the Smithsonian Astrophysical Observatory has observed the solar radiation at its station on Mount Wilson, California, altitude 5700 feet. Measurements are made by means of the pyrheliometer and spectro-bolometer at different hours of the day, so chosen that the intensity of the solar radiation as it would be outside the atmosphere at mean solar distance may be computed therefrom. During the earlier years of the investigation it appeared that the values found vary from day to day, as well as from year to year. In other words, it seemed to be indicated that the sun is a variable star, having a two-fold variation. First, a varia-